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would also cause such daily and annual fluctuations as those of the magnetic needle. Professor Norton says* that "no conception has hitherto been formed of possible atomic movements capable of originating the electric forces, and producing even the simplest of the electrical phenomena." The dependence of the polarity of the compass upon electrical currents encourages the belief that all the "possible atomic movements capable of originating the electric forces," may be traceable to some arrangement of elastic æthereal particles like the one I have above suggested. The mutual attraction of the atoms A and E is only one-third as great as that of the atoms F and G, and under the influence of centrifugal force, the several lozenges AFEG would yield most readily in the direction EG.

THE SUN-SPOT CYCLE OF 11.07 YEARS.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, May 16th,* 1872.)

The most recent and careful discussion of the observations upon the amount and frequency of Sun-spots, by De La Rue, Stewart and Loewy, † assigns to the principal cycle a duration of 11.07 years. Kirkwood (ante, vol. xi., p. 100) had previously given nearly the same estimate (11.072 years). If the spots are attributable to disturbances produced by gravitating action, the major axis of the revolving disturbing force should be $[(11.07 \div 11.862)^{\frac{2}{3}}] = .955 \times$Jupiter's, or 4.969 $\times$the Earth's major axis. The mean radius vector of perturbation is, therefore, nearly equivalent to Jupiter's mean perihelion distance (.95184♃, or 4.952⊕) as well as to the mean distance of the centre of gyration of the planetary sytem.

$\frac{2}{3} \times [(3\frac{1}{3} \times .3871 + 25 \times .7233 + 31.85 \times 1 + 3\frac{1}{3} \times 1.5237 + 9307 \times 5.2028 + 2847.4 \times 9.5389 + 416.7 \times 19.1826 + 532.5 \times 30.037) \div (3\frac{1}{3} + 25 + 31.85 + 3\frac{1}{3} + 9307 + 2847.4 + 416.7 + 532.5)] = 5.101$; $5.101 \div 4.969 = 1.0265$; $4.969 \div 4.952 = 1.0035$.

The theoretical mean excursion between Jupiter's perihelion and his mean distance, corresponds very nearly with the above value of the planetary centre of gyration.

$$4.952 + \tfrac{5}{9} \times (5.2028 - 4.952) = 5.091 \; ; \; 5.101 \div 5.091 = 1.002.$$

If Jupiter's aphelion distance represents the aphelion distance of the aggregate of forces which produce the Sun-spots, the disturbance-perihelion is $(2 \times .955 - 1.048) = .862 \times$ ♃'s, or $4.485 \times$ ⊕'s radius vector. This corresponds very nearly with the linear centre of oscillation, of the mean action of all the planets, except Jupiter, upon the Sun's surface. According to the values adopted in Norton's Astronomy, $(1-\frac{2}{3})\times(\Sigma md \div \Sigma m$ ☿, ♀, ⊕, ♂, ♄, ♅, ♆$)=4.422$; $4.485\div 4.422=1.015$.

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* Loc. cit., p. 330.

† Proc. Roy. Soc., Dec. 21, 1871; Phil. Mag., May, 1872.

The closeness of the harmony, pointed out by Kirkwood, between the Wolfian and Mercurial cycles, is very interesting. In some respects the position of Mercury is more nearly pivotal than that of either of the other planets. Its centre of explosive oscillation, relatively to the Sun, is near the limit of the Sun's possible atmosphere. $(\frac{4}{9}\times .3871)^{\frac{3}{2}} \times 365.2564 \div 25.187=1.036$. Its mean radius vector (.3871) is not much greater than the radius of the centre of oscillation (.3333) of the Earth's disturbing action upon the Sun. That centre of oscillation is, in its turn, near the centre of the counterpoising moments of inertia of the Sun and the planetary system. For $\Sigma m(d-.3333)^2 \div \Sigma m=9.0776^2$; $759.46 \div 9.0776^2 =.3294^2$; $.3333 \div .3294=1.012$. It may be well to observe that this approximation is nearly identical with the one above noted (1.015) between the virtual centre of gravity of the Jupiter-disturbing planets, and the Sun-spot disturbance-perihelion.

In order to form an estimate of the extent, to which circumstances favoring the generation or disturbance of æthereal waves affect the amount of spotted surface, I would suggest a preliminary examination of observations with especial reference to the following planetary configurations:

1. When the Sun is near the linear centre of oscillation ($\frac{2}{3}$) of two planets in heliocentric opposition: *e. g.*, near the opposition of Mercury and Venus, especially if Mercury is about 60° from perihelion; of Venus and Mars, when Mars is about 40° from perihelion; of Jupiter and Saturn, when Saturn is near aphelion; of Saturn and Uranus.

2. When one of two planets in heliocentric conjunction is near a linear centre of oscillation of the longer radius vector: *e. g.*, near the conjunction of the Earth and Mars; of Mars and Mercury, if Mars is near perihelion and Mercury near aphelion; of Jupiter and Mars, if Mars is near aphelion; of Jupiter, Saturn and Uranus, (the centre of gravity of Jupiter and Saturn being at about $\frac{2}{3}$ of the distance from Uranus to the Sun); of Saturn and Neptune, when Saturn is near aphelion; of Uranus and Neptune.

3. When one of two planets in heliocentric conjunction is near a centre of explosive oscillation ($\frac{5}{9}$): *e. g.*, near the conjunction of Mercury and Venus, if Mercury is at somewhat more than its mean distance from the Sun; of Mercury and the Earth, if Mercury is near aphelion; of Mercury, Venus, and the Earth or Mars; of Jupiter and Saturn.

ÆTHEREAL OSCILLATION, THE PRIMORDIAL MATERIAL FORCE.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, July* 19, 1872.)

In any explosive or other analogous action along a given diameter, cardinal points occur at $\frac{1}{9}$ radius and $\frac{8}{9}$ radius (=the distance from